UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D.C. 20460

OFFICE OF THE ADMINISTRATOR
SCIENCE ADVISORY BOARD

XXXX XX, 2011

EPA-SAB-11-xxx

The Honorable Lisa P. Jackson
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20460

Subject: New Office of Research and Development (ORD) Research Program Strategic Directions: Science Advisory Board (SAB) and ORD Board of Scientific Councilors (BOSC) Advice

Dear Administrator Jackson:

The EPA Science Advisory Board (SAB) and Executive Committee of ORD's Board of Scientific Councilors (BOSC) held their first joint meeting on June 29-30, 2011. The meeting offered an extraordinary opportunity to discuss ORD's new strategic research plans and to provide early input for ORD research planned for FY 2012 and beyond.

Both the SAB and the BOSC enthusiastically support ORD's consolidation of research into six research programs (four programs that map directly to your four primary strategic priorities and two cross-cutting areas). Consolidation will bring efficiencies and promote a systems approach to sustainability as an overarching framework for ORD research. Consolidation of ORD research programs and adoption of such a systems approach to sustainability are bold and necessary steps. Environmental and public health protection requires a deep understanding of environmental problems and an ability to translate problem identification and understanding into information that can empower solutions. EPA science is likely to resonate with the public if it is framed in terms of actual environmental systems, rather than traditional scientific disciplines, and if ORD can communicate how its science can be linked to preventing and solving environmental problems.

The SAB and BOSC are impressed with ORD's progress in conceptualizing the new research programs. There has been an impressive increase in transdisciplinary collaboration as well as coordination across ORD programs with the restructuring. ORD has involved regional and program office stakeholders in the design of the new programs. Program and regional support for ORD's new approaches is evident. Although one of the research programs, the Safe and Sustainable Water Resources program, has made more progress than others in formulating problems in systems terms and in articulating clearly the science activities to be undertaken to

explore and address those problems, the ORD research frameworks, over time and taken together, will help the EPA build a culture and environmental programs to promote sustainability. Finally, ORD's efforts to foster innovative research are notable. The EPA has thought seriously and operationally about ways to energize the creativity of ORD scientists and has begun to explore ways of enhancing innovation as a fundamental part of ORD programs.

The success of ORD's new research directions, of course, will depend upon implementation. Planned research must be supported by the financial and human resources needed. We recommend that the draft research frameworks each transparently describe the research goals and activities that are within the scope of ORD resources or active collaboration with external research partners. ORD must plan for the resources needed to sustain the communication, stakeholder involvement, and integrated transdisciplinary collaboration that will be essential to its new approach to research. The SAB and BOSC also underscore that all the systems of interest to EPA include human behavior. Research on relevant aspects of human behavior is crucial to understanding the systems and implementing solutions or programs that follow from them. Increased emphasis on social, behavioral and decision sciences within ORD is needed for the new research programs to be successful.

The SAB and BOSC seek continued dialogue with ORD as part of their mission to advice on the science and research supporting EPA's decisions. We look forward to any comments you have at this time on these reflections on ORD's new research directions.

Sincerely,

Dr. Deborah L. Swackhamer
Chair
Science Advisory Board

Dr. Martin Philbert
Chair
ORD Board of Scientific Counselors

NOTICE

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ORD's New Strategic Research Directions: SAB and BOSC Advice

Introduction

On June 29-30, 2011, the EPA Science Advisory Board (SAB) and the EPA Office of Research and Development (ORD) Board of Scientific Counselors (BOSC) held their first joint meeting. At ORD's request, they discussed six draft research frameworks ORD had developed for its major research areas. ORD requested SAB and BOSC advice because it is restructuring its research programs for FY 2012 to better understand environmental problems and inform sustainable solutions tomeet EPA's strategic goals. The restructured research program will be comprised of six program areas: Air, Climate, and Energy; Safe and Sustainable Water Resources; Sustainable and Healthy Communities; Chemical Safety for Sustainability; Human Health Risk Assessment; and Homeland Security. ORD had requested SAB and BOSC advice at an early stage in the process of defining strategic program directions to help ORD develop research plans to respond to EPA's strategic goals and high priority needs.

ORD requested the SAB and BOSC to address six charge questions for each of the major research areas:

a. To what extent do the draft research frameworks describe EPA's National Program and Regional Offices strategic science priorities? How well do ORD's research programs align with those priorities? If resources allow, what are areas for increased emphasis? If resources decline, what areas might be appropriate for decreased emphasis?

b. How can ORD enhance coordination among its research programs, and better ensure that they complement one another?

c. How well do ORD's proposed research directions reflect its commitment to sustainably protecting human health and the environment?

d. How do the six programs fit together as an integrated environmental research strategy, charged with informing decisions on the nation's most-critical environmental issues? Are these programs positioned to address the nation's highest priority, emerging environmental issues in the coming years?

e. Based on Board members' familiarity with efforts in the broader scientific community, how well do ORD's research programs appear to catalyze and complement environmental science programs elsewhere? What suggestions do the members have for how EPA's research programs could improve upon their leveraging with those of others?

f. How does the SAB/BOSC view ORD's activities in stimulating innovative research and what other suggestions would the SAB/BOSC have to promote innovation in EPA research?

Overarching comments

First, the SAB and BOSC strongly support ORD's consolidation of its research programs into four major programs that correspond to the Administrator's priorities plus two mission-critical research programs (Human Health Risk Assessment and Homeland Security). The consolidation of research activities within large thematic areas oriented to systems thinking and problem solving has created possibilities for enhanced collaboration across ORD laboratories and centers and stimulated transdisciplinary research in ORD. This consolidation is positive and appropriate for an organization that is seeking to foster innovation and a nimble, flexible structure for research. Managed appropriately, these larger research programs will encourage ORD researchers to reach beyond potentially narrow disciplinary limits to formulate and conduct research that meets EPA's current and future high priority needs.

Second, ORD requested advice both on how well its proposed research directions reflect its commitment to sustainably protecting human health and the environment *and* how well ORD's draft research frameworks describe and meet the strategic science priorities of EPA's national program and regional offices. As a research organization in a mission-oriented Agency, ORD must strike a balance between vision and pragmatism, or better yet, find ways to have pragmatic goals that align with a strategic vision. The concept of sustainability potentially has great power to guide and help communicate ORD research, but ORD's draft research frameworks were not equally successful in describing how ORD research relates to sustainability and how different research programs would serve regional and program needs. This variation is understandable, because different frameworks reflected research areas with different scopes and histories. The Safe and Sustainable Water Resources program has a natural focus on water systems, for example, while the Safe and Healthy Communities Program reflected a broad and novel combination of human health and ecosystem-related research.

Ideally, each research framework would include sustainability explicitly in its research vision, invoke a common definition of sustainability shared across ORD, demonstrate clearly how planned research relates to the key components of sustainability (the environment, the economy, and society), and show how regional and program office science needs will be met. As noted in the recently released report, *Sustainability and the U.S. EPA* (National Research Council, 2011), it will take time and culture change for EPA to adopt sustainability as a core principle to inform decisions and actions.

Transparency will be essential to introducing sustainability at EPA. ORD's research frameworks can advance EPA's adoption of sustainability as a core principle by more consistently and clearly describing where and how ORD research relates to sustainability. They also will need to more clearly identify legacy research that relates only minimally or tangentially to sustainability as full components of ORD's new sustainability approach. The framework documents should also be revised to more clearly describe the

research goals and activities that can be accomplished by ORD within the scope of planned resources, both human and financial. Readers of each document should be able to understand from each framework the research questions that will be addressed, the types of ORD products that would be generated, the general time frame for that activity, and how the planned activities relate to sustainability and/or science priorities of National Program and Regional Offices.

Third, ORD must plan for the human resources needed for the ambitious research described in the draft frameworks. Transdisciplinary, systems-oriented research requires coordination within and across research teams and stakeholder involvement. Both these coordination activities are time-intensive efforts. Anticipating the resources and the expertise set needed for all the activities included in the research frameworks will be critical to their success. With an increased emphasis on "systems thinking," all the systems of interest to EPA include human behavior. Research on relevant aspects of human behavior is crucial to understanding the systems and implementing solutions or programs that follow from them. Increased emphasis on social, behavioral and decision sciences within ORD is needed for the new research programs to be successful. Although ORD did not request advice about how to enhance its capacity in these areas, the SAB and BOSC provide recommendations on this important topic in Appendix F of this report.

The body of this report provides responses to ORD charge questions that are relevant to all ORD's new research programs. Appendices A-E provide responses specific to each major ORD research program.

Alignment with regional and national program office needs

The one-to-one mapping of ORD programs with the Administrator's goals provides a structure for aligning and understanding research programs in terms of EPA's strategic goals. The SAB and BOSC commend ORD for involving regional and program offices as stakeholders in the development of the research frameworks. ORD should continue to actively involve these clients in implementation of ORD research programs and evaluation of research results.

ORD internal coordination

The readily apparent increase in the amount of communication among ORD's National Program Directors and Directors of Laboratories and Centers in the development of ORD's research frameworks is a very positive development. ORD should seek to expand formal mechanisms to promote networking among internal researchers to improve research coordination throughout the research process in the least time-intensive manner. Examples of such mechanisms might include "speed dating," use of social network technology, co-location of researchers and exchange programs. Directed Requests for Applications (RFAs) that require coordination of research projects across ORD research programs can also provide an incentive to ensure coordination.

Cross-cutting issues, such as environmental justice, that are a priority of the Administrator, should be explicitly identified, wherever appropriate, as part of such RFAs to foster coordination and advance the Administrator's goals.

For both intra-mural and extra-mural research, ORD should identify priority cross-program research topics such as nitrogen and climate as vehicles for research coordination and building of interdisciplinary culture. Additional cross-cutting research topics should be explored in the future, such as multiple stressors, measures of ecosystem function, ecosystem services, energy and green infrastructure. Interdisciplinary collaboration and research coordination across all areas could be strengthened by development of community of practice "core" teams in areas such as communication, decision tools and modeling that are engaged with all six ORD research programs.

Initial planning meetings that help to frame research problems properly at the outset will enhance ORD program coordination. Internal and external stakeholders interested in or affected by ORD's research programs should participate in problem formulation. ORD scientists from other research programs should also be present to identify issues and opportunities for synergy across programs. Problem formulation that frames issues in terms of "systems thinking" and sustainability will foster increased coordination and proactive thinking to identify innovative approaches to prevent environmental problems before they occur. Social, behavioral and decision scientists provide expertise for problem formulation. Such experts can be especially useful in identifying opportunities for institutional flexibility and framing environmental problems in a larger social, economic, and institutional context.

ORD should also support research teams to enhance coordination among research programs as research programs are implemented. It will take sustained effort to maintain communication and coordination beyond the research planning phase.

As part of that ongoing coordination, ORD should identify its six research programs clearly (and not refer to them as four programs plus two cross-cutting areas) Three different conceptualizations of ORD research programs were presented graphically at the June 2011 SAB-BOSC meeting by the ORD Deputy Assistant Administrator for Science (Figure 1); the National Program Directors for the Safe and Sustainable Water and Sustainable and Healthy Communities programs (Figure 2); and the Chemical Safety for Sustainability draft research framework (Figure 3)

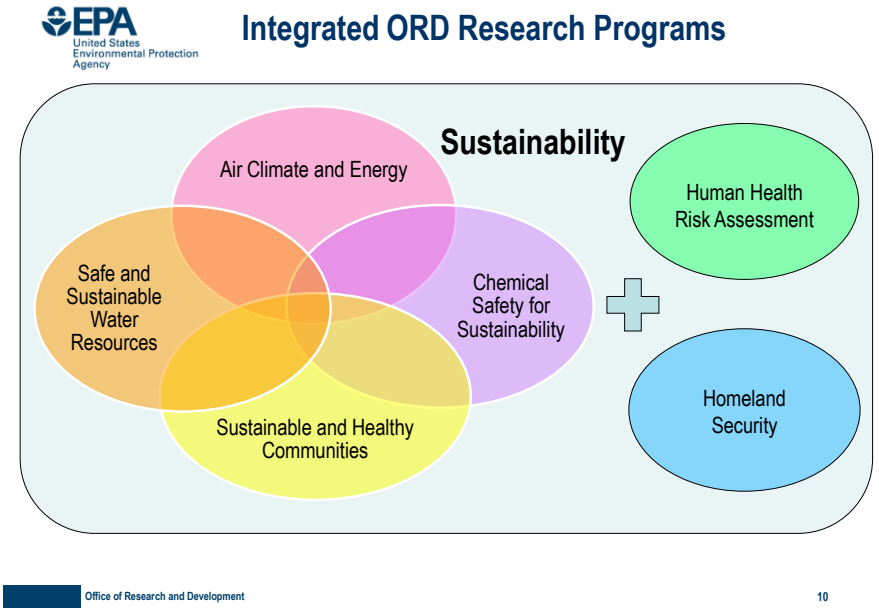

Figure 2: Slide provided by the ORD Deputy Assistant Administrator for Science

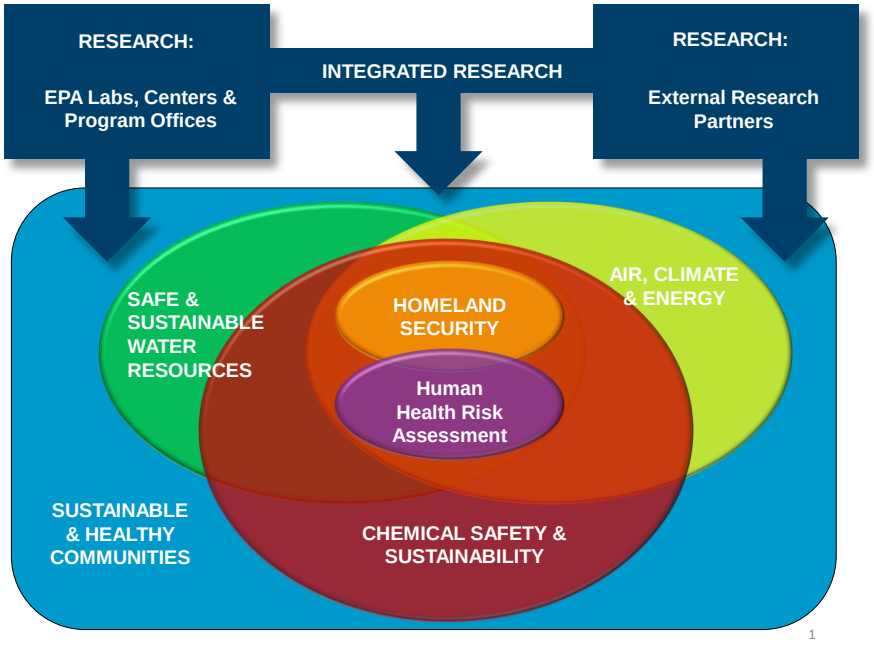

Figure 2 – Schematic used by the Safe and Sustainable Water and Sustainable and Health Communities Programs

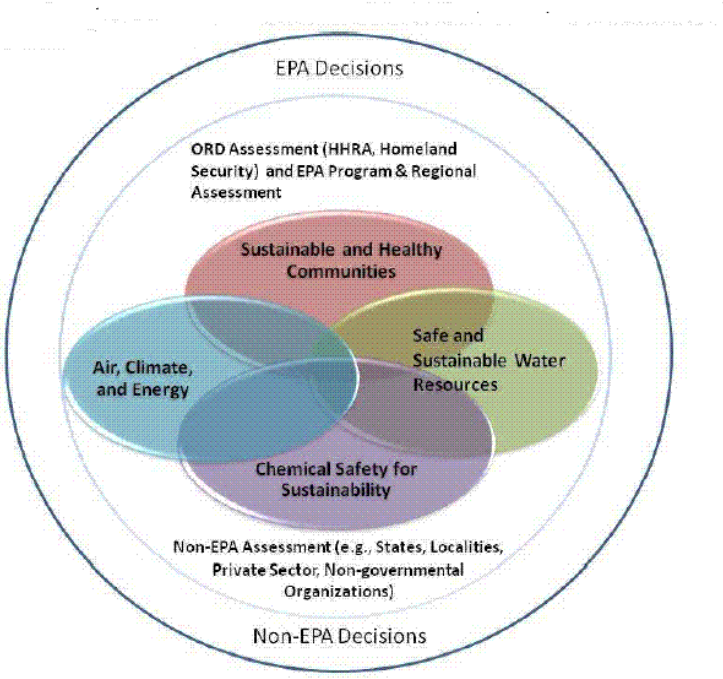

Figure 3 – Schematic used by the Chemical Safety for Sustainability Research Program

It is important to use a consistent diagram to clearly communicate how ORD research programs inter-relate and how they fit within larger EPA and stakeholder science contexts." As noted in the draft Safe and Sustainable Water framework, "To provide scientific information and tools that advance environmental sustainability, the four new national program areas must contribute to and reinforce one another, and jointly work with decision makers both inside and outside EPA." Including a common diagram illustrating how ORD research programs inter-relate and relate to external science would be useful to include in all ORD research frameworks.

In addition, such a diagram is also needed to clarify the role of the Sustainable and Healthy Communities program as an integrating force within ORD. As the research program with the largest proposed investment and a holistic, systems perspective on human health and ecosystem protection, should it be an overarching program that other programs feed into or a research program relatively separate and co-equal with other ORD research programs? A diagram that clarifies the explicit role of the Sustainable and Health Community Program in problem formulation overall for ORD research; its role in evaluation of ORD research products, as they are used by communities; and its role integrating ORD research at community levels would help to better explain the unique aspects of the Sustainable and Healthy Communities program and enhance coordination across ORD programs;

Sustainability

As noted in the general comments above, the SAB and BOSC recommend that ORD revise each research framework to include sustainability explicitly in its research vision, invoke a definition of sustainability shared across ORD, and demonstrate clearly how planned research relates to the key components of sustainability (the environment, the economy, and society). It may be appropriate for the shared definition to be consistent with the 2011 NRC report or to explain why ORD has chosen a definition different from the language the NRC chose. The NRC derived it definition from language in Executive Order 13514, which established the National Environmental Policy Act (NEPA). The NRC defined sustainability (as:

> "to create and maintain conditions, under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic, and other requirements of present and future generations" (NEPA[1969]; E. O.13514[2009]4).

ORD leads EPA in efforts to build a sustainability-oriented culture within EPA. Appendices A-E of this report provide additional detail about how different frameworks might be revised to better reflect ORD's commitment to sustainability. Clear and consistent use of the term "sustainability" in each research framework and clear linkages of the concept to research programs as they develop will require careful, continued attention. It would be helpful for all research frameworks to include a list of definitions of key terms that would be consistent across ORD's programs.

If sustainability is ORD's goal, it will be useful to develop sustainability metrics for each research program to gauge whether research helps attain sustainability goals, even if such metrics only provide early markers of these long-term goals. Without metrics, resources may not be wisely allocated and the long-term goals missed completely. This issue is complex and worthy of research in itself, because there has been a historical "disconnect" between the ideal of sustainability and the practice of regulating human health and the environment. Sustainability metrics and how they articulate with regulations would help to better define sustainability in a realigned ORD and how to achieve it.

Finally, for ORD to reflect its commitment to sustainably protecting human health and the environment, it must show leadership in two areas of research. First, ecological research must appear as a strong priority. Sustainability depends on understanding and protecting the ecosystems on which human life and all life on earth depends. Ecosystem structure, function, and services are an integral part of sustainability. Appendix D below discusses this topic in more detail. Second, because sustainability involves policy and social dimensions, explicitly integrating social, behavioral, and decision science research into ORD's research frameworks is important to demonstrate commitment to the sustainability theme.

Capacity to address current and future critical environmental issues

ORD's involvement of stakeholders and other federal partners in research planning provides a good mechanism to identify environmental issues and prioritize among them. Additional formal mechanisms for peer review and regular consultation with the SAB and BOSC and other external groups will help alert ORD to emerging issues. It may also be helpful for ORD to form an internal committee of cross-program futurists, with representatives from each research program to identify emerging issues and consult with the SAB, Bosom and other EPA groups and external stakeholders.

The most effective way for ORD to build capacity to develop responses to emerging environmental issues is to evaluate how EPA has responded to emerging science topics such as nanomaterials, the Gulf Oil Spill, hydraulic fracturing or natural disasters and identify which processes worked to anticipate those topics and to develop the needed science and which processes were not effective. Emerging environmental issues are not always predictable. Therefore, the Agency needs to be "nimble" in its research and assessment capacities to address these unpredictable issues and must strengthen its human resources and organization to provide maximum resilience. Being nimble requires that the workforce be willing and able to undertake new research tasks, work in teams, and work in new ways. ORD's re-aligned structure may enhance this by allowing a more free flow of personnel across programs to provide the expertise where it is needed in a timely fashion. Workforce "continuing education" is also a critical issue. The development of programs (visiting scholars, post-doctoral programs, or other "collaborative practices" with outside scientists) designed to develop and maintain the appropriate skill-sets within the Agency are important.

One area where ORD can increase its capacity to address future critical environmental issues is to explore the opportunities offered by "Environomics" to develop understanding of environmental phenomena through enhanced monitoring, technologies for understanding data-rich environments, data mining and data simulation. There may be new opportunities for EPA to understand the environment and pair this enhanced understanding with chemical forecasting that can be useful for predicting public health and environmental impacts. Such an approach could potentially provide new, creative, and innovative approaches for preventing and addressing the causes of complex environmental problems such as Gulf hypoxia and averting water quantity and water quality problems likely to arise from current exploitation of groundwater resources. Similarly, such research could help EPA attain a possible future where EPA could work with the "exposome" (i.e., all cumulative risks to people) and match this "exposome" information with genetic and epigenetic profiles to understand and manage environmental risks.

Ability to catalyze and complement environmental science programs outside EPA

Collaboration and joint efforts with other federal agencies and European partners is increasingly important for ORD because of the ambitious scope of ORD's new research frameworks and the limitations of EPA's budget. The Chemical Safety for Sustainability program stood out as a model for its significant efforts to develop collaborative and

complementary efforts with other federal agencies (i.e., Tox21) and European partners (e.g., the Joint Research Center in Ispra, Italy). This level of effort and coordination needs to be extended to other ORD research endeavors. ORD should actively explore formal and creative informal ways of undertaking inter-agency and international collaboration. Examples of such mechanisms include social network technology, co-location of researchers from different agencies and exchange programs among agencies.

There is a need to continuously stimulate interactions between EPA and outside scientists. One mechanism could involve a program of roundtables could be done with outside experts. Visiting scientists could be brought into the laboratories and centers for one year to cross-fertilize ideas on how to operationalize sustainability as an organizing principle at EPA.

To ensure that ORD's new research directions develop deep roots, the office should develop a mentoring and leadership development program. There will be a need to advise young researchers on their projects, publications and career objectives and to foster the culture of sustainability-related research at ORD. This internal human resource effort should complement a strategy to recruit young scientists with expertise and interest in sustainability science.

ORD should set defined goals to catalyze and complement environmental science programs outside EPA and seek BOSC review and assessment related to this topic every two years.

Innovation

ORD's efforts to foster innovative research are impressive. The Agency has thought seriously and operationally about ways of energizing the creative nature of ORD scientists and has begun to explore ways of enhancing innovation as a fundamental part of ORD programs. Creating an ORD Chief Innovation Officer position is a bold, positive step, and the Pathfinder Innovation Program is a creative and important initiative. New approaches, such as "crowdsourcing," to meet research challenges can be appropriate ways to tap creative research.

To further promote innovative research at EPA, ORD should develop metrics to programs such as Pathfinder. ORD should be able to define "failure" and "success" as part of the development of such programs and reach agreement on an acceptable "failure" rate for innovation efforts. ORD should also develop and maintain a mentoring and scientist development program that encourages creative and innovative approaches, as well as a reward system, perhaps similar to the Scientific and Technological Achievements Award program to recognize successful research that "thinks outside the box." ORD should also look for opportunities to simulate innovative research in new fields related to the social, behavioral, and decision sciences.

EPA also has a role in promoting innovative environmental research outside EPA and, indeed, in leading the country toward the adoption of more sustainable practices. Innovation could be enhanced by finding ways of making EPA data easily accessible to

the outside community of scientists who could use these data in creative ways or by emphasizing innovation in EPA's extramural grant programs. There are thousands of scientists at universities, colleges and research institutions whose expertise can be solicited through extramural research support, workshops and brainstorming sessions that bring EPA scientists together with the external science community. Highly innovative external scientists can serve as reviewers for Pathfinder proposals and projects. Consortia projects (extramural scientists working very closely with Agency scientists on a project) can help build an even greater resource of expertise and innovation throughout the country and not just at EPA. ORD might also consider a multi-agency Pathfinder Innovation Project that would tap the expertise of environmental scientists from other federal agencies. EPA needs to drive innovative research within the community.

Innovation often comes through the coming together of scientists from different fields, as well as scientists from different organizations (pure academic research, industry, non-governmental organizations, other federal agencies, state and local governments). Thus, symposia where the Agency can present proposed approaches and ask for feedback from outside the Agency would be extremely helpful.

Appendix A: Air, Climate and Energy

Background

ORD is reorganizing this research program around sustainability and environmental solutions. The draft research framework identified the following problem statement:

> Protecting human health and the environment from the effects of air pollution and climate change, while sustainably meeting the demands of a growing population and economy is critical to the well-being of the Nation and the world. As we explore solutions to prevent and reduce emissions, we are challenged by uncertainties surrounding the complex interplay between air quality, a changing climate, and a changing energy landscape, and the subsequent human health and ecological effects attributed to exposure to an evolving array of pollutants in the atmosphere.

The draft framework identified the following problems as the focus of attention:

- The multipollutant nature of air pollution in order to develop effective air quality strategies;
- The impacts of climate change and the interactions between adaptation and mitigation;
- The human health and environmental impacts of current and future energy options;
- The populations most susceptible to poor air quality and the populations and ecosystems most vulnerable to climate change;
- The expanding and contracting scales of environmental problems that range from global to local; and,
- The social, behavioral, and economic factors that influence the effectiveness of air quality and climate policies.

The vision articulate in the framework is:

> To provide cutting-edge scientific information and tools to support EPA's strategic goals to take action on climate change and improve air quality.

The draft framework proposed that ORD would provide the policy-relevant research needed by EPA partners to assess impacts, prevent and reduce emissions, and respond to changes in climate and air policy.

General observations:

The vision for the Air, Climate and Energy program includes sustainability as a paradigm for research, but there exists a fundamental disconnect between sustainability and the legislative mandates of the Clean Air Act. ORD should address clearly it will integrate the two needs for research and how it will trade off between them. This tension will grow and may increasingly need to be addressed if EPA's budget is constrained. One possibility is to build on EPA's historic strengths. Air Quality Monitoring has been a

major strength of ORD in the past and it contains a unique opportunity for changing the future. Sensor development and reporting networks opportunities are ripe if research is undertaken wisely. In the past, the EPA has conducted monitoring for the sake of compliance. EPA might consider shifting or using some of that monitoring for decision-making and hypothesis testing as well.

In the climate arena, biofuels is one area where EPA has a mandate to prepare an annual report to Congress on green house gas effects from biofuels and the Renewable Fuel Standard. Since EPA really has little authority related to energy and little authority on climate other than that provided through the Supreme Court ruling and the Endangerment Finding, the lack of legislative authority could free ORD to unfettered and innovative, creative research.

Alignment with regional and national program office needs.

In general, the draft framework reflects the strategic science priorities of programs and regions. The SAB and BOSC support the increased emphasis on energy choices and the nexus between air, climate, and water. A focus on multi-pollutants also integrates well with this emphasis. Research directed at single pollutants is being restructured within the multipollutant framework and that is appropriate. The framework should be revised to describe more clearly where multi-pollutant efforts were under way and the sequencing of different multi-pollutant activities.

Despite its strengths, however, the framework could better describe transdisciplinary nature of the research needed. More emphasis is needed on climate change research to reduce greenhouse gas emissions, both from a technological standpoint (like carbon sequestration) and also from a social and behavioral standpoint (how to get the desired environmental behavior from people and industry without mandates or command-and-control legislation). Research in the social, behavioral and decision sciences is needed on how people come to understand climate change, their risk perceptions and what motivates them to take action. How do these attitudes develop? People value present goods far more than future goods (discounting). What would make technologies be perceived as being viable? How do we ensure adoption of sustainable technologies? In addition, the intersection of science and policy should be a distinct research area within Air, Climate and Energy. This topic has been a lively focus of research for the past ten years (citations) and the Intergovernmental Program on Climate Change has fostered research on the relationship of policy to science that could be useful to ORD.

It will be important for the Air, Climate and Energy program to regularly check that research is aligned with regional and national program office needs. Research should begin with the question in mind, clearly stated and framed properly. The National Research Council Silver Book (National Research Council 2009) provides a good guide in this respect. ORD should conduct regular synthesis activities to determine whether the research conducted has solved the problem and to identify additional knowledge gaps. In this effort, ORD should formulate the question (hypothesis) clearly and then research its every aspect holistically. One example might be: “black carbon should be the first pollutant to be regulated for overall Air, Climate and Energy program effectiveness

including air quality/human health, climate change mitigation, and energy choices." Appropriately, programs that have fulfilled their original objectives, like the near road program, leave room for other program areas to grow, like biomass. Some modeling exercises like source apportionment may be ready for decreased emphasis. Biomass could be emphasized for a period, and then be sunsetted. However, such synthesis activities could help illuminate unintended consequences as when biomass programs result in wood burning in a school boiler. Smoke exposure to children presents potential hazards that need to be examined.

ORD internal coordination.

The Air, Climate and Energy program is closely related to the Sustainable and Healthy Communities and the Safe and Sustainable Water Resources research programs. Integrated assessments, driven by particular problems at the community, regional or national levels can be used to bring them together. Addressing problems related to climate change or water quantity may provide useful foci for assessments.

Sustainability.

ORD should reference sustainability as a new paradigm for driving research in the Air, Climate and Energy framework. The vision statement for this research program as well as the problem statement should explicitly reference sustainability. The framework should explicitly address the possible "disconnect" between the ideal of sustainability and the practice of regulating human health and the environment, as required by the Clean Air Act. Sustainability metrics and how they articulate with regulations would help to better define sustainability in a realigned ORD and how to achieve sustainability. The SAB and BOSC recommend that ORD undertake research to define the benefits of moving from a more technology-based regulatory system to a performance-based regulatory system that "incentivized" sustainable solutions (one engineering innovation that might be considered is smart metering, for example, to encourage energy and water conservation; meters could be read in dollars saved in addition to kilowatts per hour). This approach may result in ancillary benefits of decreasing the cost of regulations to the regulated community and stimulating innovation. ORD can help EPA change the paradigm for environmental protection through identifying sustainable alternatives risk managers' consideration. ORD should expand its current portfolio to help decision makers identify and understand decision options related to sustainability. ORD could design and analyze scenarios related to changing air quality and different strategies for adapting to climate change. Any adaptation strategy will almost certainly be accompanied by environmental consequences that might be the focus of ORD research.

ORD should consider programs to sponsor senior academic researchers for one-year visiting sabbaticals to seek their suggestions about how to transform the Air, Climate and Energy program into a program fully integrating sustainability.

Capacity to address current and future critical environmental issues.

ORD's six research programs fit together and offer the possibility of addressing environmental issues that go beyond EPA's direct statutory mandates. The appendix to the draft Air, Climate and Energy draft framework articulates science questions and areas of integration within the research program and across ORD programs. Cross-cutting issues such as nutrients (i.e., reactive nitrogen) and climate change are highlighted the discussion. This design provides an effective roadmap for current and future critical issues and collaboration across ORD research programs. The Appendix could even be more effective if it were extended to include collaboration with other key research partners, such as the Department of Energy.

Innovation.

The Air, Climate and Energy program should encourage and stimulate relevant behavioral, social, cognitive and decision research both within the Agency and extramurally. As an example, research is needed on how to persuade people to change their behaviors regarding energy use. Examples include being receptive to smart meters, converting to compact fluorescent bulbs, buying higher mileage cars, etc. There is a huge amount of basic research to be conducted on the psychology of persuasion, on the subjective time-discounting factors that affect people's willingness to spend resources now for future gains, and on risk communication. The SAB and BOSC recommends that the Air, Climate and Energy program bring in a few senior behavioral, social, cognitive, and decision science experts for one year visiting sabbaticals to cross-fertilize this new area.

Appendix B: Safe and Sustainable Water Resources

Background

ORD has restructured its historical Drinking Water and Water Quality research programs into a single research program called Safe and Sustainable Water Resources. The new program strives "to develop sustainable solutions to 21st century water resource problems by integrating research on social, environmental, and economic outcomes to provide lasting solutions." The draft research framework identified the following problem statement:

> Increasing demands for sources of clean water, combined with changing land use practices, growth, aging infrastructure, and climate change and variability, pose significant threats to our Nation's water resources. Failure to manage our Nation's waters in an integrated, sustainable manner will limit economic prosperity and jeopardize both human and aquatic ecosystem health.

The draft framework explicitly identified two major challenges:

1. Provide the best science in a timely manner to allow faster, smarter management decisions on our existing problems; and
2. Get our science out in front of tomorrow's problems by developing and applying new approaches that better inform and guide environmentally sustainable behavior.

Two research themes are identified:

> Research Theme 1 – Sustainable Water Resources: Ensure safe and sustainable water quality and availability to protect human and ecosystem health by integrating social, economic and environmental research for use in protecting and restoring water resources and their designated uses (e.g., drinking water, aquatic life, recreation, industrial processes, and other designated uses) on a watershed scale.
>
> Research Theme 2 –Sustainable Water Infrastructure Systems: Ensure the sustainability of critical water resources using systems-integrated water resource management where the natural, green and built water infrastructure is capable of producing, storing and delivering safe and high-quality drinking water, and providing transport and use-specific treatment of wastewater and storm water.

The framework articulates the vision for this research program as follows:

> Safe and Sustainable Water Resources uses an integrated, systems approach to research for the identification and development of the scientific, technological and behavioral innovations needed to ensure clean

and adequate and equitable supplies of water that support human well-being and resilient aquatic ecosystems.

Alignment with regional and national program office needs.

The Safe and Sustainable Water Resources draft framework effectively describes the alignment of ORD's research with regional and national strategic goals. It also describes an effective prioritization process for identification of research focus areas. The prioritization process was notable for its engagement with a wide range of internal and external stakeholders. It will be important for this research program to continue to engage with a wide range of stakeholder groups, including EPA programs and regions, as research activities develop. If budget cuts require future reductions, the prioritization process now in place should enable determination of the highest priority needs and activities that can be deferred or cut.

The integration of the drinking water and water quality research programs is a very positive development and will provide important new synergies especially with respect to water treatment technologies relevant to drinking water, wastewater, and storm water; evaluation of microbial risks; and evaluation of aquifer storage and recovery.

ORD internal coordination

The framework includes a section describing how the research program is designed within the context of ORD's restructured research programs. As noted in the body of this SAB-BOSC report, Figure 2 included in this SAB-BOSC report, which appears in the Safe and Sustainable Water Resources framework, provides an effective way to communicates how the research program inter-relates with ORD science and science generated outside ORD.

Sustainability.

The Safe and Sustainable Water research topics were clearly formulated with the sustainability theme as guide. The framework provides a useful list of definitions that explain what is meant by sustainability and a "sustainable solution."

Ability to catalyze and complement environmental science programs outside EPA.

ORD should evaluate existing mechanisms for inter-agency collaboration and build on them to maximize the potential to catalyze and complement environmental science programs outside EPA. Programs such as Strategic Environmental Research and Development Program, FERN, the Chesapeake Bay Program and a variety of programs created by U.S. Department of Agriculture's Natural Resource Conservation Service (e.g., the Mississippi River Healthy Basins Initiative, rural programs for small communities, animal feedlot management programs) offer opportunities to learn from and build upon. Such mechanisms can be used to promote networking with external researchers.

The draft framework provides an excellent, detailed description of research needs, objectives and science questions that identifies where science activities of partners exist to complement ORD's efforts and where collaboration with EPA is needed to stimulate partner's research on topics of importance to EPA.

Innovation

The draft framework identifies opportunities to use the Science to Achieve Results (STAR) grant program to support technical development and innovation goals. Specific detail is provided within the overall context of objectives and science questions. Innovative technologies are especially important to the water infrastructure theme. The Small Business Innovation Research program may be a resource for this particular area.

Social, behavioral and decision sciences.

Social science issues permeate all of the priority research topics for the Safe and Sustainable Water Research program. Social science research should be integrated in all of the programs in explicit ways. Appendix F of this report provides more detail on the types of science and research that might be most useful and how ORD might undertake or collaborate to obtain the science and research needed.

Appendix C: Homeland Security

Background

ORD's Homeland Security Research Program has a focused mission and did not provide a draft research framework that included a "problem statement" or "vision statement." The draft framework described the mission of the program in this way: "to conduct research resulting in science and technology products that increase the Agency's capability to meet its homeland security responsibilities, thereby assisting communities' build their resilience. The program's goal is to plan, execute and produce these products in close concert with our Agency partners so that the results of this program are used by these partners in implementing their homeland security programs. A secondary goal of the program is to design research and it products so that they address natural and inadvertent disasters to the greatest extent possible."

The research framework identified five major themes:

A. Research to Help Protect Water Infrastructure against Attacks
B. Research to Improve Detection of Contamination and Mitigation of Exposure in Water Systems
C. Research to Improve Characterization of the Nature and Extent of Contamination
D. Research to Improve Risk Assessments and Communication
E. Research to Improve Cleanup of Contamination

Alignment with regional and national program office needs.

There is alignment of the Homeland Security draft research framework with program and regional strategic goals, within the limited scope of the program's mission and an effective prioritization process for identification of research focus areas. The Homeland Security program has developed effective ongoing engagements with numerous stakeholders and partners, including a formal program of continuous partner engagement. If budget cuts require effort reductions, the prioritization process now in place should enable determination of what can be cut while ensuring that the program continue to meet highest priority needs.

The Homeland Security Program is not as far along in developing its framework as the Safe and Sustainable Water Resources program.

Regions that have natural disasters can help with identification of research needs for the Homeland Security Research Program in unique ways. The program is well positioned to address natural disasters and is doing so in some ways already. The program should consider expanding research and capabilities in relation to natural disasters. There appear to be important needs and opportunities in several areas, including climate change and adaptation.

ORD internal coordination and ability to catalyze and complement environmental science programs outside EPA.

The Homeland Security model of coordination within and outside the EPA can be a model for other areas. Within EPA, the program works with Agency clients to plan, implement and deliver useful science products. By the nature of its mission, the program must actively coordinate with the Department of Homeland Security, the Department of Defense, and the Centers for Disease Control and Prevention. ORD should evaluate these processes to develop lessons learned to apply to other ORD research programs.

Sustainability.

The linkage of the Homeland Security research topics with sustainability is not transparent, but the overall program objective of helping communities become more resilient is the sustainability link. ORD should revise the research framework to explain this linkage more clearly.

Appendix D: Safe and Healthy Communities

Background

The draft research framework identified the following goal:

> to inform and empower decision-makers to equitably weigh and integrate human health, socio-economic, environmental, and ecological factors into their decisions in a way that fosters community sustainability.
>
> To achieve this goal SHC will provide information, approaches, and tools that will help decision-makers in communities and in federal, state and tribal regulatory and community-driven programs to more effectively and transparently assess current conditions in the built and natural environments, to evaluate the implications of alternative policies and management actions, and to identify indicators to measure results.

The draft framework identified the following problems as the focus of attention:

> Current trends in population and the way we use of energy, food, and materials have created environmental threats to sustainability that include the erosion of critical ecosystem services and the compromised ability of the environment to tolerate increasing levels of pollution. While technological breakthroughs will likely continue to slow some negative environmental trends, we still face many challenging problems. Not only are human health and ecosystem services negatively affected by cumulative exposures to multiple toxic pollutants and a changing physical environment, these effects also have economic and social implications, such as resultant costs for health care, cost for technologies to replace some ecosystem services, and costs to enhance social justice, at scales ranging from local to international. Because of the increasing pressures on the environment, it is clear that future approaches to protecting human health and the environment will not support sustainability over the long term if they:
>
> - Fail to adequately consider the inextricable link between our natural environment and human well-being, including economic and social aspects;
> - Focus on regulating one energy or materials stream or chemical at a time, rather than on preventative strategies or strategies that optimize management of multiple chemical and energy streams in order to achieve the most environmentally beneficial, cost-effective and socially acceptable outcome; or
> - Lead to unintended consequences, or fail to produce valuable co-benefits, because of a lack of systems thinking.

The draft framework identified three major themes:

> Theme 1: Working with communities to develop comprehensive approaches to become more sustainable.
>
> Theme 2: Developing decision analysis methods, tools, models, data, and metrics that support community sustainability.
>
> Theme 3: Targeting high-priority agency research, i.e., Contaminated Site Management and Restoration; Waste and Materials Management- Support for Regulations, Policy, and Guidance; Nitrogen- Support for Regulation; Environmental Justice Topic; Children's Health; and the Report on the Environment.

General comments.

The Sustainable and Health Communities research program is visionary; community-based outreach and interaction are essential to sustainability. The new research area frames environmental issues in positive terms and is not bound by narrow regulatory constraints. As a result, it has the potential to catalyze public support for environmental protection and for the EPA. Several other aspects of the program also are unique: 1) it focuses on the local or community level (rather than on national-level issues) because it is place-based; 2) it takes a holistic, systems perspective; and 3) it focuses on stakeholder participation and collaboration. As a result, this ambitious program requires a great deal of new and challenging research on place-based environmental problems and social, behavioral, and decision science issues. ORD, however, does not currently have the required expertise, especially in social, behavioral and decision sciences.

The SAB and BOSC understand the value of providing decision support for communities ("empowering" local decision making), but find that the draft framework does not clearly describe the decision-makers/stakeholders or discuss whether the objectives of decision-makers necessarily reflect community objectives. Essential questions regarding the definition of the relevant community and whether community objectives align with broader national objectives are not articulated, much less answered in the document.

The framework should articulate a clearer vision for ORD's role in providing assistance to communities. Will ORD provide decision tools or technical support at some initial phase or will it be an active participant in implementing tools? ORD does not currently have experience or expertise in community-based implementation and will need to develop both if implementation is the vision. The framework should describe clear expectations for ORD's planned community work, as well as an "exit strategy" so all readers will understand how far ORD's commitment to active engagement with communities goes.

The nature and level of integration of research across the three themes within the Sustainable and Health Communities program is unclear. The three themes represent very different kinds of activities and include 'cutting edge" research, as well as support of

"conventional" regulatory mandates. Theme 1 is the most innovative, but will receive less than ten percent of the program's resources initially. EPA's commitment to this novel activity most be robust and sustained for the program to take root and grow.

Finally, the Sustainable and Healthy Communities program includes essentially all of the ecological research in ORD. As such, there is a need to support ecosystem science within this program. Ecosystem services and benefits are contained as one component, among others, in Theme 2 of the SHC Research Program. The draft framework contains no discussion of ecosystem science apart from ecosystem services and benefits. There is a concern that ecological research, as well as the science necessary to understand ecosystem services and benefits, could well be under-funded and under-emphasized in the proposed research structure.

Ecosystem science, which has seen a continued decline over the past years and has been reduced to only $60 million, about ten percent of the ORD budget. is important for several reasons. Ecosystem science is vitally important for understanding how ecosystems function. From the perspective of EPA, ecological research is important for understanding ecological processes that underlie healthy ecosystems and the quality and quantity of the services offered by ecosystem to communities. In addition to understanding ecological processes, there is important research needed, both ecological and social science research, to translate ecological processes to ecosystem services, to analyze the benefits to the community of these services and to predict the changes in the provision of services that would result from various actions/policies/behaviors.

Consequently, SAB and BOSC support continued, or enhanced, support for ecosystem research.

Alignment with regional and national program office needs.

The Sustainable and Health Communities program clearly reflects an effort to integrate the Administrator's top priorities at the community level. Within the program, areas for increased emphasis might include children's health; social, behavioral and decision science research; and epigenetics to provide markers of exposure to chemicals. Integrated transdisciplinary research and coordination across ORD programs should provide some efficiencies and ORD may identify areas for reduced emphasis, if it finds that other agencies' environmental research programs can complement EPA's research efforts.

ORD internal coordination.

The Sustainable and Health Communities program can serve an essential "coordinating" role for ORD by working with communities to define sustainability goals and framing problems in terms of a broad systems approach that reduces media-specific and disciplinary silos. One vision for the program is for it to use, test, and evaluate research products from other ORD programs and provide feedback to guide more focused research from those programs in the future. The program can help integrate environmental research and problem solving at the national and local levels. ORD should revise the draft

framework for the Sustainable and Health Communities program to describe its role within ORD more clearly and consider some of the functions described above.

Sustainability.

At a theoretical level, the Sustainable and Health Community program directly reflects ORD's commitment to sustainably protect health & environment. The SAB and BOSC's introductory general comments in this Appendix, however, identify concerns about how this program will be operationalized at the community level and concerns about possible misalignment between local and national perspectives

Capacity to address current and future critical environmental issues.

This visionary program potentially would have the capacity to address current and future critical environmental issues, but it will need to identify clearly where EPA/ORD will provide leadership and where it will play a supporting role in addressing issues. Success implementing activities related to Theme 1 depends on effective partnerships with other agencies and non-governmental organizations as they work with communities to address high priority issues.

As noted above, the Sustainable and Health Communities program may not necessarily align with national priorities if goals of communities differ from national priorities.

Ability to catalyze and complement environmental science programs outside EPA.

ORD's progress in adopting integrated transdisciplinary research is consistent with momentum elsewhere to pursue such integrated approaches. ORD has made a positive commitment to focus on ecosystem services and has developed important partnerships with other agencies and nongovernment organizations, but there are significant additional opportunities to work with other countries and international research organizations to advance ecosystem science and research and bring these results to EPA and local decision makers. CITATION

There are also opportunities to complement and leverage research with the Department of Energy and Department of Defense on site contamination and cleanup issues and to explore partnerships with non-governmental organizations that that work closely with communities.

One area for focus is to develop effective mechanism for catalyzing, complementing and leveraging research in the social, behavioral and decision sciences. ORD should explore new opportunities to partner with the National Science Foundation to support extramural research in this area and to serve as a clearinghouse for community-level data and metrics related to sustainability (e.g., "urban metabolism")

Innovation.

Community-based research offers a wide variety of new opportunities for innovation. ORD should promote opportunities for community-based data collection, monitoring and reporting, subject to standard quality controls. The Sustainable and Healthy Communities program would benefit from investments in related technological innovation, such as hand-held monitoring devices or mobile phone applications for collecting and transmitting environmental or public health data. Such new technologies would involve new ways to engage communities, which would be a focus of innovative research in itself.

Social, behavioral and decision sciences.

The Sustainable and Healthy Communities program offers many potential roles for social, behavioral, and decision sciences. Such sciences can help with: 1) problem formulation, development of systems perspectives, and identification of alternatives; 2) engagement in participatory processes; 3) understanding behavior, behavioral responses and incentives; and 4) evaluation of alternative options and tradeoffs (e.g., impact analysis, benefit-cost analysis). Research on this topic is essential to the success of the program. ORD, however, does not currently have capacity, internally or through external funding, to do this research.

It will be important for ORD to explore how other agencies have engaged social, behavioral, and decision scientists (e.g., Forest Service, U.S. Department of Agriculture in other programs, Department of the Interior management of wildfire risks, National Oceanic and Atmospheric Administration, National Park Service) in place-based environmental decisions. Appendix F of this report describes how ORD might begin to develop a capability in these disciplines and access expertise outside EPA.

Appendix E: Chemical Safety for Sustainability and Human Health Risk Assessment

Background

The draft research framework for the Chemical Safety for Sustainability program identified the following problem statement:

> Although chemicals are essential to modern life, we lack innovative, systematic, effective, and efficient approaches and tools to inform decisions that reduce the environmental and societal impact of chemicals while increasing economic value.

The vision articulated in the framework is:

> EPA science will lead the sustainable development, use, and assessment of chemicals by developing and applying integrated chemical evaluation strategies and decision-support tools.

The Chemical Safety for Sustainability identified the following objectives:

- Creating tools that inform sustainable chemical/material design and use
- Developing methods for much faster screening and prioritizing
- Providing the scientific knowledge and tools to effectively understand real-world risks
- Developing assessment approaches that are tailored to specific decision contexts
- Considering where impacts may occur throughout a chemical's life cycle.

The draft framework for the Human Health Risk Assessment program identified the following problem statement:

> Agency decisions must be based on defensible scientific evaluations of data relevant to assessing human health impacts. Currently, the demand for such assessments is not being fully met, particularly in terms of the number of existing and new chemicals in need of assessment, the types of risk characterization outputs needed to inform decision making, and the tools and data needed to support assessments.

The vision articulated in the framework is:

> The Agency will generate timely, credible human health risk assessments to support all priority Agency risk management decisions, thereby enabling the Agency to better predict and prevent risk.

The four primary themes of the Human Health Risk Assessment program are:

- Integrated Risk Information System (IRIS) health hazard and dose-response assessments;

- Integrated Science Assessments (ISA) of Criteria Air Pollutants;
- Community Risk and Technical Support for exposure and health assessments; and
- Methods, models, and approaches to modernize risk assessment for the 21st century

Alignment with regional and national program office needs.

In general, the draft framework documents were written from a theoretical perspective. The SAB and BOSC recommend that ORD revise the documents so they more clearly communicate the intended research and its strategic science priorities. The term "sustainable" and its derivative forms were used in different ways in the draft documents and there was little explanation of its meaning. It would be useful to define this term as it is employed in the documents. In addition, there were several other definitional problems, e.g., inherency, etc., that have internal meaning at EPA but are not well known to others. The SAB and BOSC recommend that the terms employed in the framework documents are fully defined, concisely, operationally, and not theoretically.

In revising the frameworks, EPA should include a short (~ three-page) executive summary that concisely identifies the key points in the document and a one-page text box/bubble diagram of the research programs and their integration is recommended to clearly map the reorganization structure. The documents should more clearly convey the goal of integrating and coordinating research efforts as well as integrating the ways in which research priorities are developed and utilized.

It is evident that ORD is increasing efforts to collaborate internally across research programs and across program and regional offices and that the Chemical Safety for Sustainability program and the Human Health Risk Assessment program are aligned with regional and program office needs. Integration appears to be occurring in the way decisions are made concerning priority setting for ORD, as well as with the other Agency offices. ORD should identify more clearly in the research frameworks where there are novel science products that will occur because of this coordination/alignment with regional and program office stakeholders and how these outputs would be measured. Clear metrics should be developed and deployed that track how this realignment changes the effectiveness of Agency actions so that these efforts can be evaluated.

Regarding prioritizing programs for increased or decreased emphasis, the SAB and BOSC recommend that ORD conduct analyses that would help develop criteria for prioritization. Because it is difficult to predict specific issues for the future, it will be important to have a focused and well defined path for strategic and rapid responses to emergencies is important. An analysis of the lessons learned from the 2010 Gulf oil spill may help identify gaps. The Agency should conduct or support research to understand the public's perception of uncertainty and risk assessment. Shedding some light on public attitudes and knowledge will enable the Agency to communicate the science more effectively. Social, behavioral, and decision science research on this topic will help EPA identify how to address these factors. ORD should conduct analyses to help prioritize research based on scheduled regulatory needs and other deadlines and also the need to fill data gaps. Once such analyses are conducted, ORD should define clear short-term and long-term goals that can be measured with respect to what is to be achieved, how much money/effort it should take and the timetable needed.

The draft frameworks should better articulate social, behavioral, economic and decision science needs because these will assist the Agency in linking priorities to desired outcomes. This should be emphasized regardless of resources.

Streamlining across agencies (e.g., Food and Drug Administration, U.S. Department of Agriculture; Food and Drug Administration; U.S. Geological Survey, National Institutes of Health; National Center for Toxicological Research; National Toxicology Program, and National Institutes of Health) should continue so that redundancy is minimized. Collaborative efforts need to be defined and the process transparent to minimize any tendency for compartmentalization (i.e., creating 'turf lines' or stovepipes). Collaborations such as Tox21 will provide a better ability to leverage the resources of various agencies toward the EPA mission. This may require a common lexicon to be developed across agencies.

Given EPA's role as a leader in environmental research, extramural research is an important way for the Agency to tap the talent and enhance innovation at universities and other research institutions. Extramural research will increase the agency's ability to react flexibility to changes in priorities and associated personnel expertise needs. SAB and BOSC, however, note that extramural programs should not be undertaken in *lieu* of or at the expense of EPA's intramural research activities. The frameworks should establish crisp and specific "goals and objectives" (or milestones and timetables) with respect to research to be executed and associated metrics (as well as anticipated costs; with respect to manpower and hard dollars).

ORD internal coordination.

Directed extramural grants that require coordination of across ORD programs are likely to stimulate integration and coordination. Cross-cutting issues, such as environmental justice, need to be overtly part of those grants. Environmental justice is listed as a priority for the Administrator but is not specifically listed as a research program. More articulation of this priority is needed in the frameworks to ensure that it is not forgotten.

Likewise, social, behavioral and decision sciences should be specifically articulated in both the Chemical Safety for Sustainability and Human Health Risk Assessment frameworks. For instance, in sections discussing risk assessment, it should be noted that research could provide some answers to the Agency's understanding of how the public perceives "exposure" versus "contamination." The Agency has spent a great deal of time and effort to get the technical science right, but if the public does not understand the very basics of how the Agency makes its decisions and misunderstands concepts like "uncertainty" then the Agency will continue to work against the very public it seeks to protect. The Human Health Research Assessment program may be able to foster greater public understanding of EPA risk assessment by adding new information to the Integrated Risk Information System process, for example, as recommended by the NRC 2009 report *Science and Decisions* (e.g., by providing for public input into the design of a risk assessment in its formative stages or by exploring how assessments can be used to evaluate the relative merits of various options for managing risk) to help people use the information in its products more effectively. The first step is to understand where citizens are with their thinking about chemical safety and risk assessment. The next steps are to address those gaps appropriately.

Sustainability.

The draft frameworks should clarify the use of the term sustainability and related terms. It would also be useful to develop a set of metrics that would be required elements to gauge if sustainability is attained (early markers of this long-term goal). Without metrics, resources may not be wisely allocated and the long-term goals missed completely.

Ability to catalyze and complement environmental science programs outside EPA.

EPA is a clear leader in the fields of environmental sciences – both in terms of technology development and in terms of research in a wide variety of fields that supports the technology. For a variety of reasons, academia and industry have fallen behind and it is important for EPA to support and enhance current efforts. This could be enhanced with focused extramural grants on topics of translational or targeted science. In the area of toxicity testing, the National Center for Computational Toxicology (NCCT) has made a significant effort to develop collaborative and complementary efforts with other federal agencies (i.e., Tox21) and European partners (e.g., the Joint Research Center in Ispra). This level of effort and coordination needs to be extended to other ORD research endeavors.

ORD's research programs are generating novel scientific information that is not yet used in regulatory programs. Mechanisms need be developed to bridge this gap between ORD's innovative work of ORD and the scientific information actually used for decision making. This would include both the translation of this work into risk assessment as well as the incorporation of this work into guidelines employed by risk assessors. There should also be more coordination between the Chemical Safety for Sustainability program with programs such as Design for the Environment to reciprocally enhance the activities of each.

The SAB and BOSC recommend that ORD explore mechanisms for industry-government collaboration. There are good examples of industry-government collaboration in Europe, Australia and New Zealand and this might be a useful model for the Agency to explore. Citations. Identifying ways to reduce controversy between industry and government over individual risk assessments could possibly stimulate industry funding of toxicology research programs in academic institutions and strengthen the nation's overall environmental research capability.

Appendix F: Expanding ORD Capabilities in Social, Behavioral, and Decision Sciences

The SAB, BOSC and other science advisory bodies have over several decades repeatedly recommended expansion of social, behavioral and decision sciences expertise at EPA.[1] To protect human health and the environment, the EPA has traditionally focused on risks from single pollutants in a single medium addressed through end-of-pipe technical controls and the specification of standards. As the focus has shifted to mixes of multiple-pollutants interacting through multiple environmental media to affect particular individuals and communities, new research is needed to support appropriate and effective policies. This research must, for example, address the impacts of human behavior on the production, use, dispersion and disposal of pollutant mixtures, variations in individual and community exposures and susceptibility to

[1] Recent advice related to to social, behavioral, and decision science from the SAB

- Science Advisory Board Comments on the President's Requested FY 2012 Research Budget (EPA-SAB-11-007)
- Office of Research and Development Strategic Research Directions and Integrated Transdisciplinary Research (EPA-SAB-10-010); Valuing the Protection of Ecological Systems and Services (EPA-SAB-09-012);
- EPA's Strategic Research Directions 2008: An Advisory by the EPA Science Advisory Board (EPA-SAB-09-006);
- Comments on EPA's Strategic Research Directions and Research Budget for FY 2008 - An Advisory Report of the U.S. Environmental Protection Agency Science Advisory Board (EPA-SAB-07-004);
- Science and Research Budgets for the U.S. Environmental Protection Agency for Fiscal Year 2007; An Advisory Report by the Science Advisory Board (EPA-SAB-ADV-06-003);
- Science and Research Budgets for the U.S. Environmental Protection Agency (EPA) for Fiscal Year 2006 - An Advisory Report by the EPA Science Advisory Board (EPA-SAB-ADV-05-002);
- Advisory Report on the Science and Research Budgets for the U.S. Environmental Protection Agency Fiscal Year 2005;
- A Report by the EPA Science Advisory Board (EPA-SAB-ADV-04-003); Toward Integrated Environmental Decision-Making (EPA-SAB-EC-00-011)

Selected National Research Council reports related to social, behavioral and decision science at EPA the potential incorporation of SBDS into EPA programs:

- New Directions in Climate Change Vulnerability, Impacts, and Adaptation Assessment: Summary of a Workshop (2008) With effective climate change mitigation policies still under development, and with even the most aggressive proposals unable to halt climate change immediately, many decision makers are focusing unprecedented attention on the need for strategies to adapt to climate changes that are now unavoidable.
- Population, Land Use, and Environment: Research Directions (2005) reviews knowledge on interactions between demographic and environmental changes mediated by land use and recommends research directions.
- Decision Making for the Environment: Social and Behavioral Science Research Priorities (2005) identifies five areas of high priority research that can contribute to improved decisions affecting environmental quality.
- Human Interactions with the Carbon Cycle: Summary of a Workshop (2002) reports on discussions of promising research issues linking social science and natural science analyses of the carbon cycle.
- Human Dimensions of Global Environmental Change: Research Pathways for the Next Decade (1999) presents a state-of-the-field review and set of research imperatives.
- Research Needs and Modes of Support for the Human Dimensions of Global Change (1994) led NSF to support a collection of centers and research teams.
- Science Priorities for the Human Dimensions of Global Change (1994) advised the National Science Foundation on the creation of a policy science program to deal with global change issues.

toxins, and impacts on the capacity of supporting ecosystems to absorb and transform toxins to less hazardous or even beneficial forms.

The June 2011 joint review of ORD research plans by the SAB/BOSC reinforced the recommendation for expansion of social, behavioral, and decision science capabilities. The transformation of ORD to a transdisciplinary systems-oriented approach centered on sustainability requires a balanced program of research that integrates environmental (natural) sciences with economic and social sciences, and ORD capabilities in the last two areas continue to be grossly inadequate. Specific social, behavioral and decision scientists needs were identified for each of the individual program areas along with "cross-cutting" needs relevant to all program areas. The following summarizes SAB and BOSC responses to four key questions relating to social, behavioral and decision sciences in ORD:

1. What specific roles should social, behavioral and decision sciences fill in meeting science/decision support responsibilities relevant to the realigned ORD research programs (i.e., what might social, behavioral and decision scientists do)?
2. What specific sub-disciplines/fields of social, behavioral and decision sciences might best meet identified research and decision support needs?
3. Where might individuals having the relevant types of training, experience and expertise be found (e.g., what types of academic programs, research organizations, etc)?
4. How might social, behavioral and decision sciences best be organized and supported within the EPA/ORD research and development programs and systems?

Specific roles social, behavioral and decision scientist might play in ORD

At the broadest level two general roles were identified for social, behavioral and decision scientists. First, as addressed by the ORD/BOSC workshop on applications of decision sciences (March 2009), social, behavioral, and decision science principles and expertise could be used to improve the way ORD decides, plans and implements its own research activities. For example, social, behavioral, and decision science could be productively applied to elucidate and manage the often problematic boundary between science and policy and to identify and investigate alternative innovative ways to achieve policy goals. Second, social, behavioral, and decision science expertise is needed to support the various specific ORD research and decision support activities carried out within and across the six major program areas by systematically investigating individual, community and institutional values, perceptions, motivations, knowledge, beliefs and behaviors that affect, and are affected by, EPA efforts to protect human health and the environment.

Discussion groups for all of the ORD program areas had little difficulty identifying numerous areas in which specific social, behavioral, and decision science research and expertise was needed. The most common areas for application of these sciences were:

1) perception/understanding of environmental risks and of mitigation alternatives, including awareness, knowledge and feelings associated with particular environmental risks and policy situations;
2) communication/education affecting understandings, feelings and actions relevant to protecting human health and the environment generally and for particular environmental policy contexts;

3) judgment and decision making, including both rational and emotional components;
4) behavior change for individuals, communities and institutions to foster and sustain support for agreed upon policy goals; and
5) values, motives and world views that discriminate among various constituencies/stakeholders and affect their preferences for and reactions to alternative environmental policies.

These potential roles for social, behavioral, and decision science capabilities research and application are quite consistent with and reinforce the conclusions arrived at independently by the ORD National Center for Environmental Research Behavioral/Social Science Town Hall held on June 2011.

Specific sub-disciplines/fields of social, behavioral and decision science that might best meet identified research and decision support needs

Social, behavioral, and decision sciences encompass a large and diverse set of disciplines. Each major discipline includes many sub-disciplines and only a small portion of any social, behavioral, and decision science capabilities discipline is devoted to (or relevant to) the protection of human health and the environment as defined within the authorities and aspirations of EPA. Thus, ORD should be quite selective in recruiting the social, behavioral, and decision scientists to help meet the research and decision support needs identified above. Moreover, the social, behavioral and decision scientists must be capable of working effectively in a professional context that by tradition and by legislative authority emphasizes physical/chemical/biological sciences. The success of the ORD effort to effectively develop, integrate and nourish social, behavioral and decision science capabilities depends jointly on the general success of the transformation toward a truly transdisciplinary systems oriented research organization and on the selection of the individual social, behavioral and decision scientists who will enthusiastically join and effectively work within that organization.

A list of disciplines and sub-disciplines potentially appropriate to ORD social, behavioral and decision science needs is presented below. This list is not comprehensive, but at the same time it is also too long to be of much use in actual recruitment efforts, especially given current constraints. The availability of scientists with relevant expertise and interests within each sub-discipline varies as does the current representation within ORD (ranging from none in most cases to a few in the case of economics, for example). Additional interactions between the SAB, BOSC and ORD could help to extend, prune, refine and most importantly prioritize this list.

Initial list of relevant social, behavioral and decision science disciplines and sub-disciplines

Discipline	Sub-disciplines
Psychology	environmental perception, pro-environmental behavior, risk perception, attitude assessment, attitude-behavior associations, environmental beliefs
Sociology	social impact analysis, diffusion of innovation, social networking, social capital assessment/development, social influence, compliance processes, community involvement
Decision sciences	judgment, decision making, value construction, deliberative group decision making, tradeoff identification/negotiation,

Communication	persuasive communications, science communication, strategic communications, public relations/affairs
Education	environmental education, environmental interpretation
Political science	public policy, environmental policy, institutional behavior, inter-governmental relations
Geography	hazard perception, environmental hazard mitigation, demographics,
Economics	applied economics, ecological economics, resource economics, agricultural economics, behavioral economics

Where ORD might find scientists with the relevant types of training, experience, expertise and interests be found (e.g., what types of academic programs, government agencies, research organizations, etc)?

There are social, behavioral and decision scientists working in a great many academic, government and private research and application contexts, any of which might be a productive source for filling ORD's needs. However, it is more likely that appropriate individuals will be found in interdisciplinary programs that specifically include collaborative education, research and applications related to environmental science and policy. Several federal agencies have considerably more experience with the development and use of social, behavioral and decision science, including the Department of Agriculture (notably the Agricultural Extension Service and the Forest Service) and the National Oceanic and Atmospheric Administration, which recently expanded and integrated social, behavioral and decision science into its Sea Grant program. Applied economics departments, integrated environmental science and policy/management programs, engineering programs that provide opportunities for minors in sustainability/social sciences/law, as well as the National Science Foundation-funded Integrated Graduate Education and Research Training (IGERT) programs are likely sources. A few specific programs (by no means a comprehensive list) that could be sources of relevant SBDS personnel include Columbia University's Center for Research on Environmental Decisions (CRED), the Annenberg School of Communications at the University of Southern California, a program in behavior change theory at the University of Minnesota, and several programs at Carnegie Mellon University that allow natural scientists and engineers to add social science skills (or social scientists to add engineering or natural science skills). Several members suggested scanning the editorial boards and the authors publishing in relevant interdisciplinary journals, including but not limited to *Journal of Environmental Psychology, Journal of Environmental Economics and Management, Society and Natural Resources, Journal of Risk and Uncertainty,* and *Risk Analysis* as a way to develop lists of potential individuals and institutions.

How might social, behavioral and decision science best be organized and supported within ORD??

There is a consensus that ORD must have some full time, in-house expertise in social, behavioral and decision science. At the very least, such individuals are needed to access and properly interpret existing social, behavioral and decision science principles and data relevant to ORD's mission, as well as to guide ORD toward the development of useful new social, behavioral and decision science information and science. The SAB and BOSC have little enthusiasm (or optimism) for the development of a separate social, behavioral and decision science program within ORD. The greatest consensus was for a cross-cutting organization, with social, behavioral

and decision science supported within each of the major programs. Several members suggested that there should be at least one social, behavioral and decision scientist at a relatively senior level in each of the six ORD research program areas. These individuals would be charged with directing social, behavioral and decision science activities in their assigned program and would work regularly with the social, behavioral and decision scientists in other programs to coordinate social, behavioral and decision science activities across ORD. To effectively integrate social, behavioral and decision science in the realigned ORD research programs, social scientists will need to be involved in problem formulation and in the design, development and implementation of all research and decision support efforts. Several members were concerned that the ORD attend to the needs for "critical mass," physical proximity and effective communication among the social, behavioral and decision scientists and that performance evaluation and reward programs should recognize the special cross-cutting roles of social, behavioral and decision scientists.

Additional social, behavioral and decision science capability for specific projects could be recruited through post doctoral appointments and, at a more senior level, through targeted sabbatical leave support and/or special government employee programs or other visiting or temporary appointment procedures. For longer term development of social, behavioral and decision science capacity directly relevant to EPA, ORD should increase its support of relevant extra-mural social, behavioral and decision science research grants and other programs that encourage development of educational programs that provide skills and experiences needed by social, behavioral and decision scientists who might work in the EPA context.

It was generally assumed, and generally supported, that ORD should develop and shape social, behavioral and decision science capacities over time, learning as they go what their greatest needs are and how best to fill them. At the same time, consensus was very strong that this process needs to start now! Members of the SAB and the BOSC expressed a strong interest and willingness to assist ORD in meeting social, behavioral and decision science needs that have been apparent for some time.

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